Data Visualization (CIS/DSC 468)

Definitions

Dr. David Koop
What is Data Visualization?
What are the purposes of visualization?
Exploration <-> Communication Spectrum

Consecutive Starts by a Quarterback for a Single Team

Exploration <-> Communication Spectrum

Consecutive Starts by a Quarterback for a Single Team

Questions

Answers/Persuasion

Where have you seen visualizations?
Books / Posters

[Rock 'N' Roll is Here to Pay, R. Garofalo, 1977]
Books / Posters

[Rock 'N' Roll is Here to Pay, R. Garofalo, 1977]
Web

[Music Timeline, Google Research]
What is the advantage of the second version?
Interaction
Visualization Exploration and Communication
## MTA Fare Data Exploration

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MTA Fare Data Exploration
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East 161st Street and River Avenue

Full Fares Purchased

Date

08-02 08-09 08-16 08-23 08-30 09-06 09-13 09-20 09-27 10-04 10-11 10-18 10-25 11-01
MTA Fare Data Exploration

East 161st Street and River Avenue

New York Yankees

August

September

2013 Regular Season Schedule

D. Koop, CIS 468, Spring 2017
Administrivia

• Course Web Site
• Syllabus
  - Plagiarism
  - Accommodations
• Textbook
  - Munzner (required)
  - Murray (available online)
• Assignments
• Exams (2 + Final, 3 Total)
• Registration
  - Add/Drop Deadline Friday
Textbooks

Munzner

Murray
Do not cheat!
Do not cheat

• Cheating on assignments, projects, and exams is not allowed
• You will receive a zero on the assignment/project/exam
• It will be reported to the department and university
• If it repeats, you will fail the course
• You can be kicked out of the university
Do ask questions!
Do ask questions

• If you are stuck on a specific issue with an assignment:
  - Do email me with **specific** questions
  - Do consult books, online documentation, tutorials
  - Do discuss that specific issue with a classmate

• If you are asked about a question:
  - Do not share your code
  - If the questioner is trying to cheat, walk away
  - If you see an obvious mistake, kindly point it out
  - Suggest a specific function or library that may be useful
Definition of Visualization

“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.”
— T. Munzner
Definition

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“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.”
Why People?

- Certain tasks can be totally **automated**
  - Statistical computations
  - Machine learning algorithms
  - We don’t need visualization for these tasks (although perhaps for debugging them…)
- Analysis problems are often **ill-specified**
  - What is the correct question?
  - Exploit human visual system, pattern detection capabilities
  - Goal may be an automated solution or a visual analysis system
- Presentation
  - It is often easier to show someone something than to tell them a bunch of facts about the data (and let them explore it)
Why Computers?

[Cerebral, Barsky et al., 2007]
Why Computers?

[Cerebral, Barsky et al., 2007]
Resource Limitations

- Memory and space constraints
- How many pixels do I have?
- Information Density

[McGuffin & Robert, 2010]
Definition

“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively”
Why Visual?

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[F. J. Anscombe]
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Mean of x 9
Variance of x 11
Mean of y 7.50
Variance of y 4.122
Correlation 0.816

[F. J. Anscombe]
Why Visual?

[F. J. Anscombe]
Visual Pop-out

Visual Pop-out

Visual Pop-out

Visual Perception Limitations

Visual Perception Limitations

Another Test

• https://www.youtube.com/watch?v=0grANlx7y2E
Other Human Limitations

- Visual working memory is **small**
- **Change blindness:** Large changes go unnoticed when we are working on something else in our view
“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively”
Design Iteration

Design Iteration

Design Iteration

Each streak shows consecutive starts by a quarterback for a single team. Streaks include playoffs.

Only two players have longer streaks: Brett Favre (275) and Eli's brother, Peyton (227).

Among active players, Philip Rivers (122) and Joe Flacco (96) are closest behind Eli.

Find a quarterback

Eli Manning (149)

Another Design Example

Each solid circle represents a bee species active in Carlinville, Ill., in both the late 1800s and 2010.

Hatching represents a bee species active in the 1800s but now locally extinct.

The spot where each block rests on the circle indicates one of 26 plant species frequented by these bees.

In the 1880s scientists observed the following about the bee-plant encounters:

- Present
- Frequent
- Abundant

Studies in 2009 and 2010 showed many bee-plant interactions had changed:

- Lost
- Persisted
- New

[M. Stefaner, 2013]
“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively”
Why Effectiveness?

• “It’s not just about pretty pictures”
• Any depiction of data requires the designer to make choices about how that data is visually represented
  - Analogy to photography
  - Lots of possibilities (see quarterback study)
• Effectiveness measures how well the visualization helps a person with their tasks
  - How? insight, engagement, efficiency?
  - Benchmarks and user studies
Effectiveness

Average Annual Global Temperature in Fahrenheit
1880-2015

[S. Hayward, 2015]
Effectiveness

Year

Year (A.D.)

@bizweekgraphics
Effectiveness

Average Annual Global Temperature in Fahrenheit
1880-2015

[S. Hayward, 2015]
Analyzing Visualization

Why?
How?
What?

Why?
How?
What?

Why?
How?
What?

Dependency

[Munzner (ill. Maguire), 2014]
How do we create modern visualizations?
Tools

• Desktop Applications:
  - Excel (see excelcharts.com)
  - Tableau
  - …

• Programming Frameworks
  - Processing
  - OpenFrameworks
  - d3.js
  - …

• Advantages and disadvantages
  - Speed, customization, understanding
**D3.js** is a JavaScript library for manipulating documents based on data. **D3** helps you bring data to life using HTML, SVG, and CSS. D3’s emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework. Combining powerful visualization